

Long-term monitoring of Blazars with dedicated Cherenkov telescopes

Blazars hosting Binary Black Holes?

Blazars as hadronic accelerators?

FACT: The **F**irst G-**A**PD **C**herenkov **T**elescope

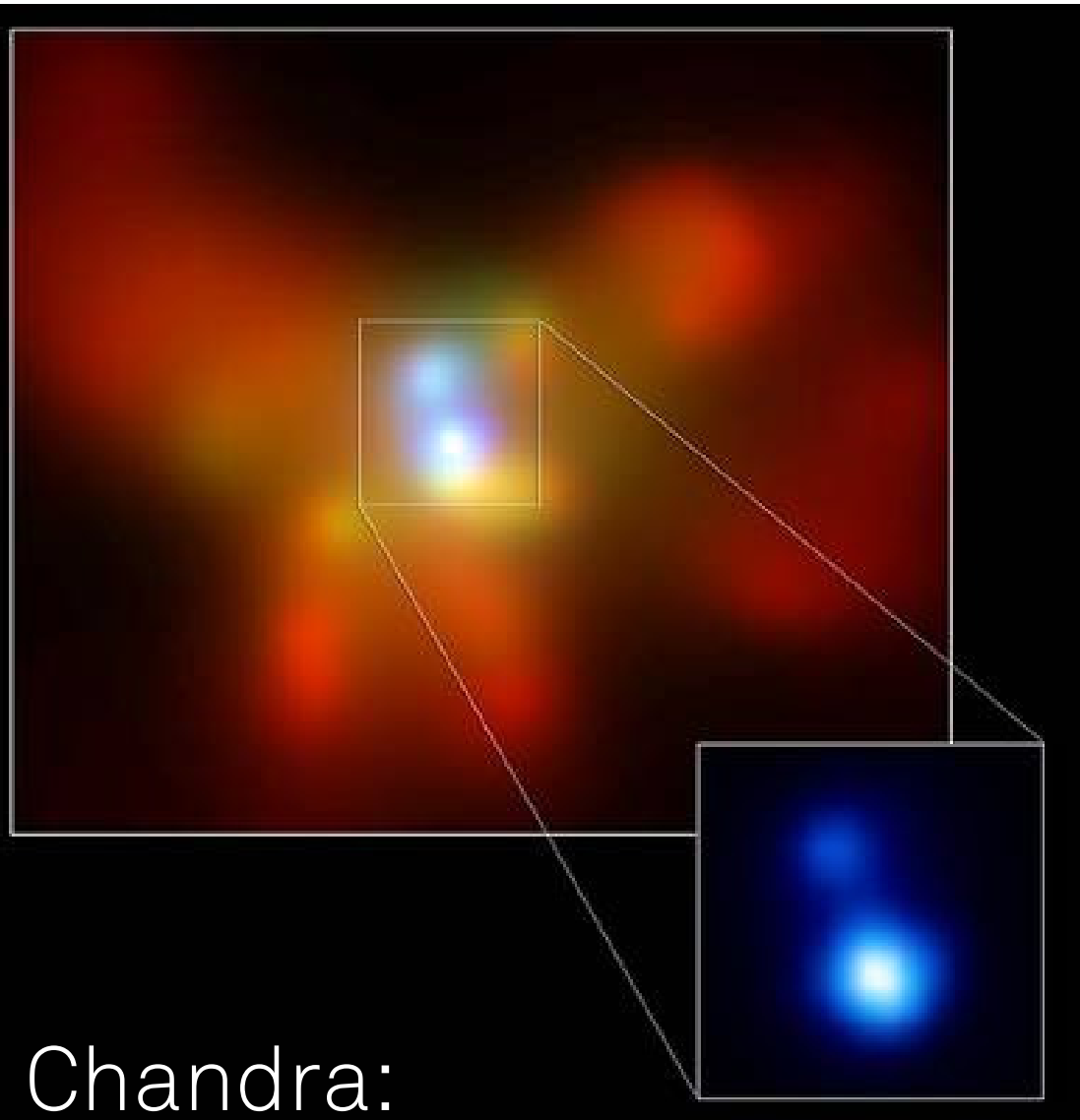
DWARF: A global IACT network

Summary

Michael Backes
for the DWARF collaboration

Acknowledging support of

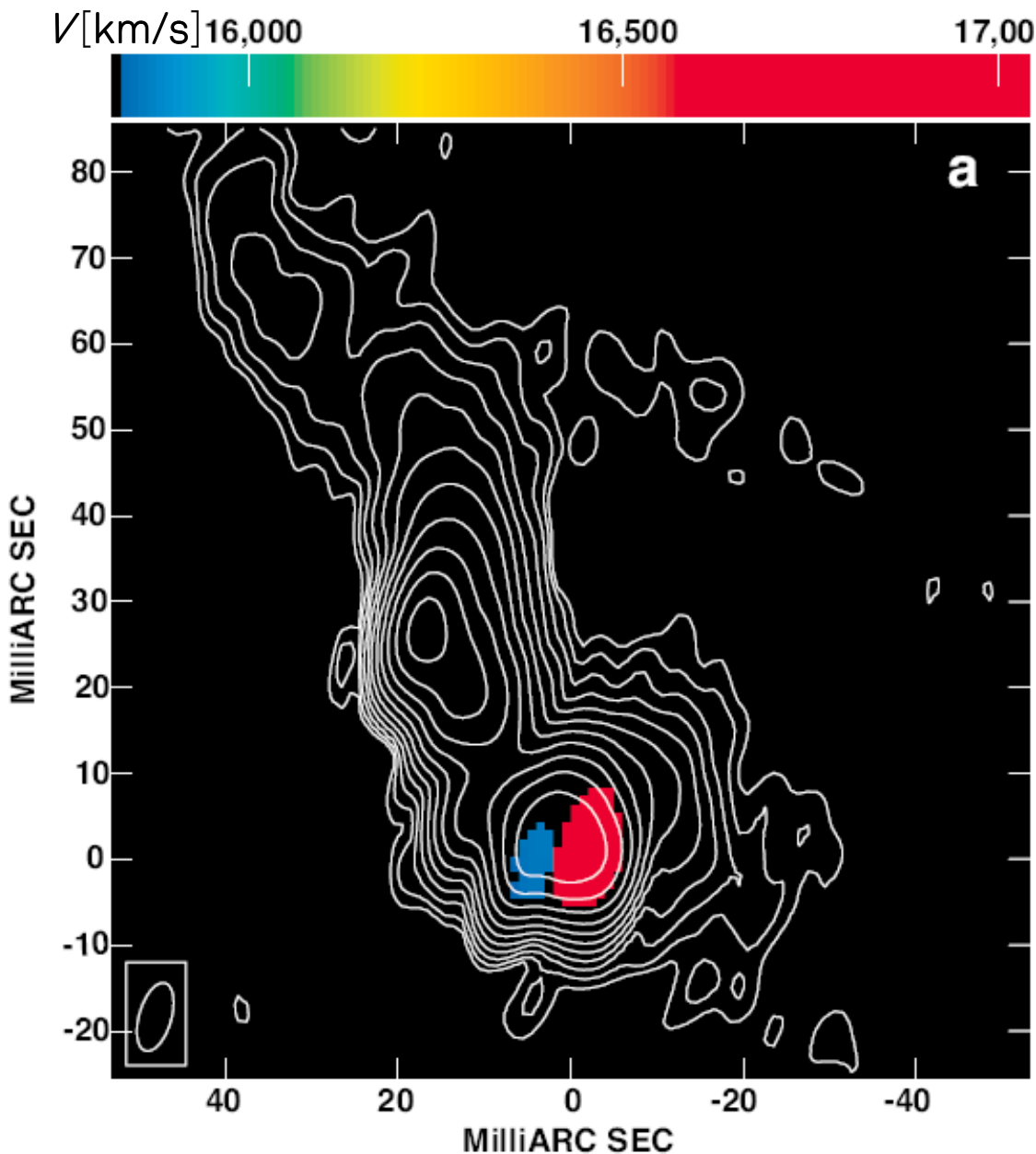




Chandra:

NGC 6240: $z=0.024$;
 $d \sim 1.4 \text{ kpc}$, 2 active Nuclei
[Komossa+03]

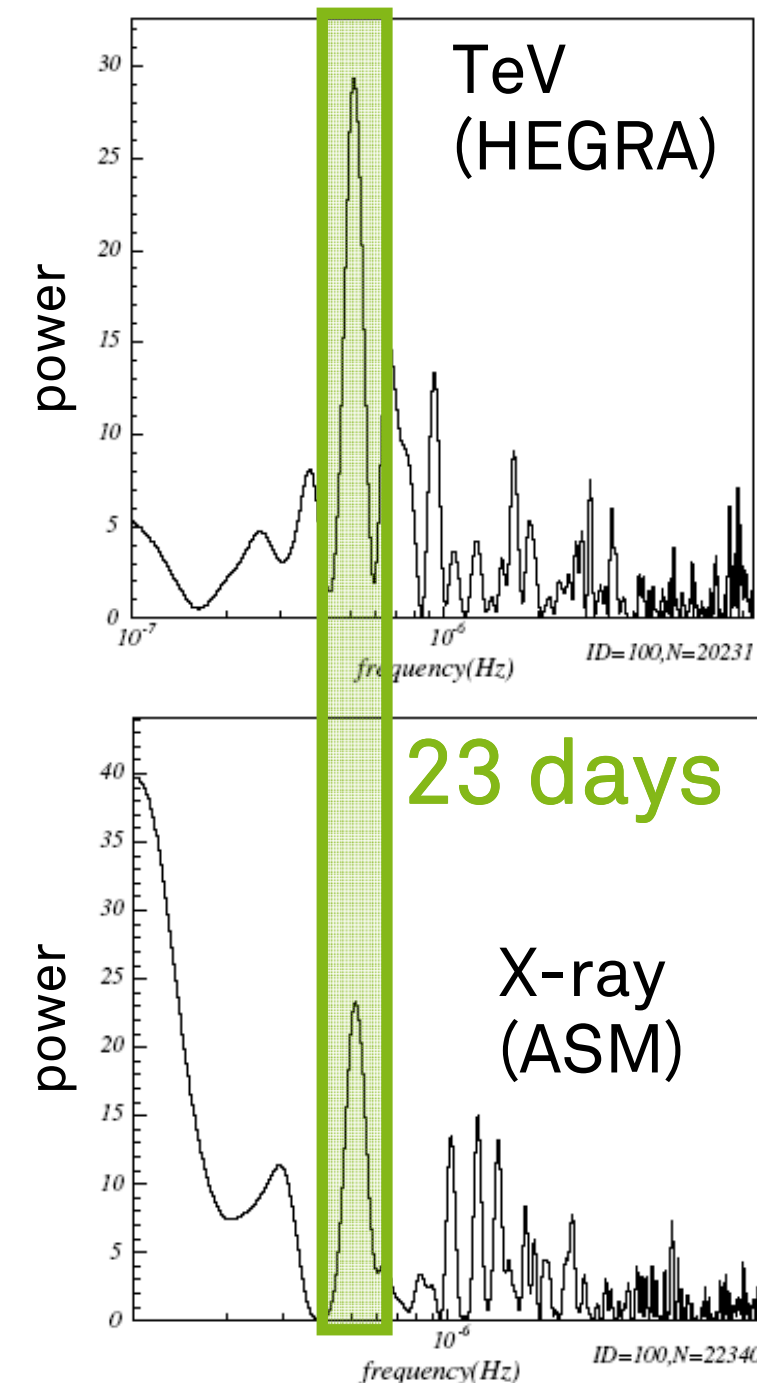
- Natural expectation of hierarchical galaxy formation
[e.g. Begelman+80]
- Discovery of wide (kpc) BBHs
- Model of merger kick-off by asymmetric grav. wave emission
[Komossa+08]
- Discovery of 1 narrow (7pc) BBH
[Rodriguez+09]
- 1 candidate (in SDSS) of sub-pc BBH from 2 BLRs
[Boroson+09]
- Are there close to coalescence sub-pc scale BBHs?



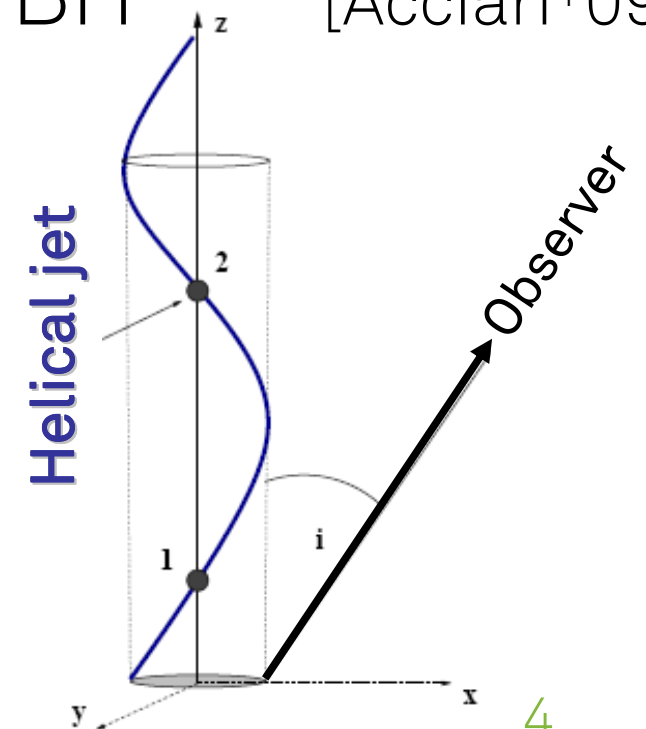
VLBI: HI-velocity

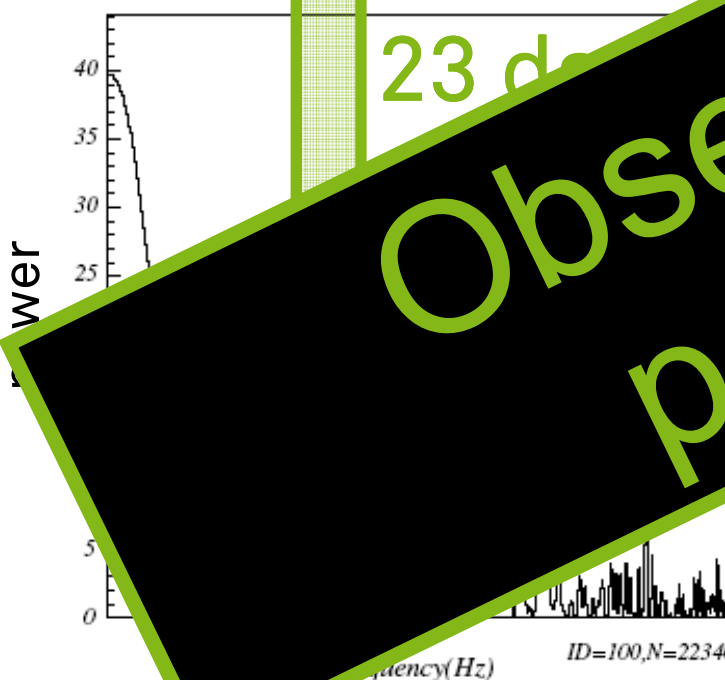
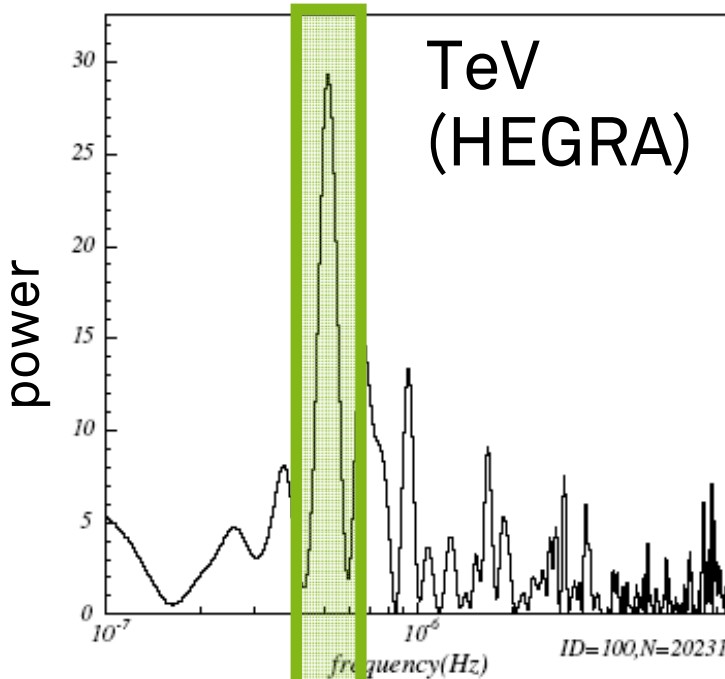
0402+379: $z=0.055$; $d \sim 7$ pc

- Natural expectation of hierarchical galaxy formation
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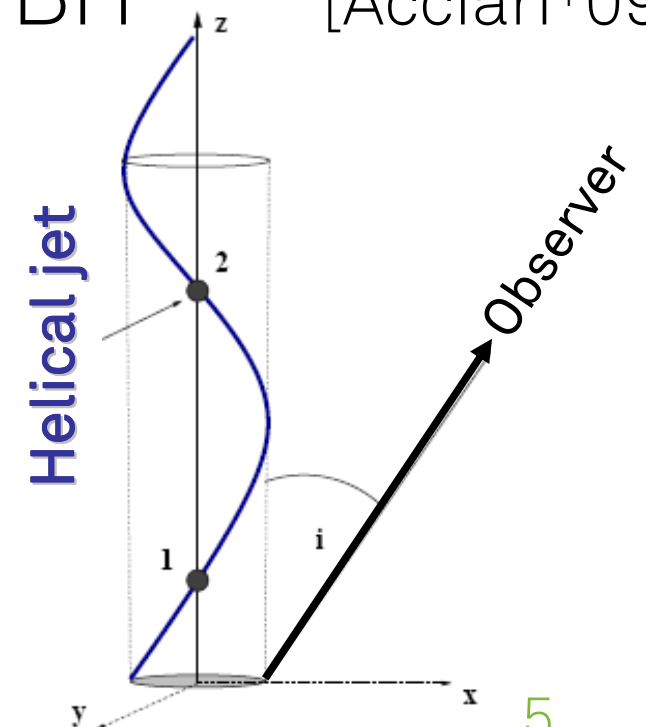
- Theory: narrow BBHs would cause quasar like peak luminosities [Lobanov06]
- Not resolvable → Search for QPOs
- OJ287: 12 yr optical [Sillanpää+87, Fan+98, Wu+06]
- Mkn501: TeV & X-ray: 23d [Kranich+99, Osone06]
optical: 100d [Yang+08]
new TeV & X-ray: 23d, 36d & 72d [Rödig+09]
- TeV emission from close to BH [Acciari+09]
- Interpretation of QPO in TeV as BBH [Rieger & Mannheim00, De Paolis+02, Rieger07]
- ⇒ Extract mass & distance
- ⇒ Calculate GW templates





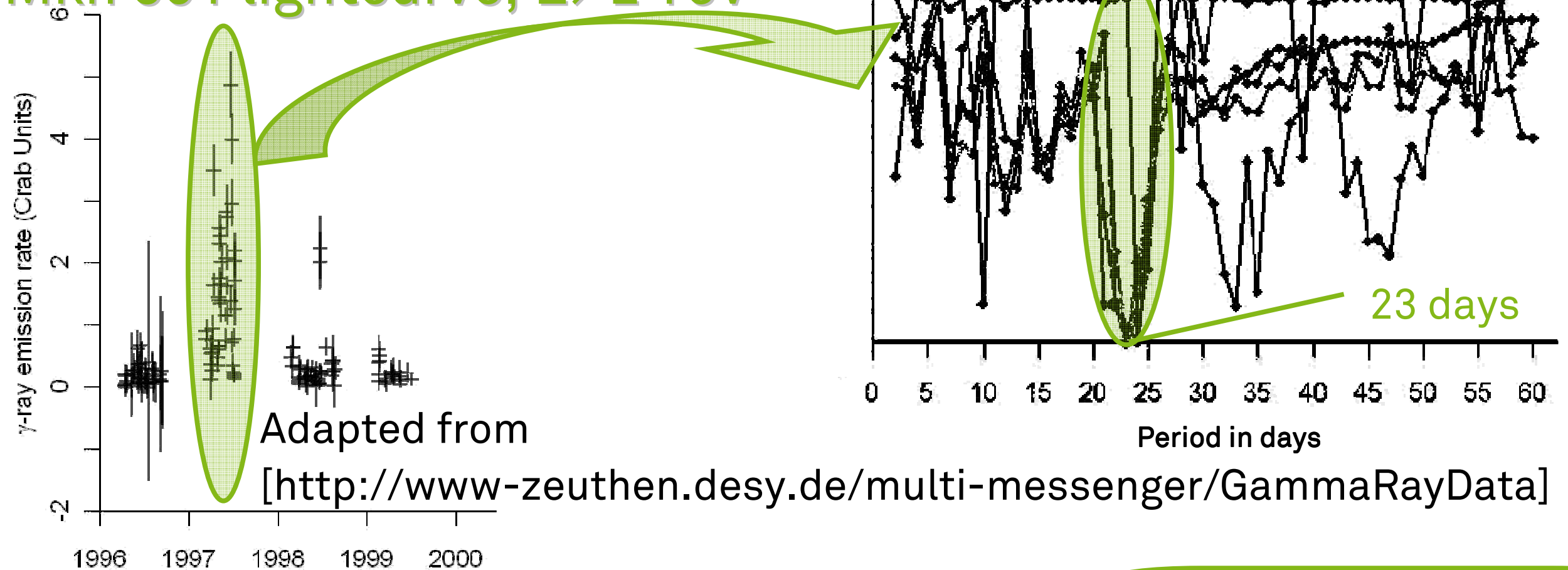
- Theory: narrow BBHs would like peak luminosities [Ghisellini & Tavecchio 06]
- Not resolvable \rightarrow [Ghisellini & Tavecchio 06]
- OJ287: 12 y [Ghisellini & Tavecchio 06]
- Mkn509: 23 d [Ghisellini & Tavecchio 06]
- from close to BH [Yang+08]
- observation of QPO [Rödig+09]
- TeV as BBH [Acciari+09]
- [Rieger & Mannheim00, De Paolis+02, Rieger07]

- ➡ Extract mass & distance
- ➡ Calculate GW templates



Long-term periods in TeV emission? ...looking back...

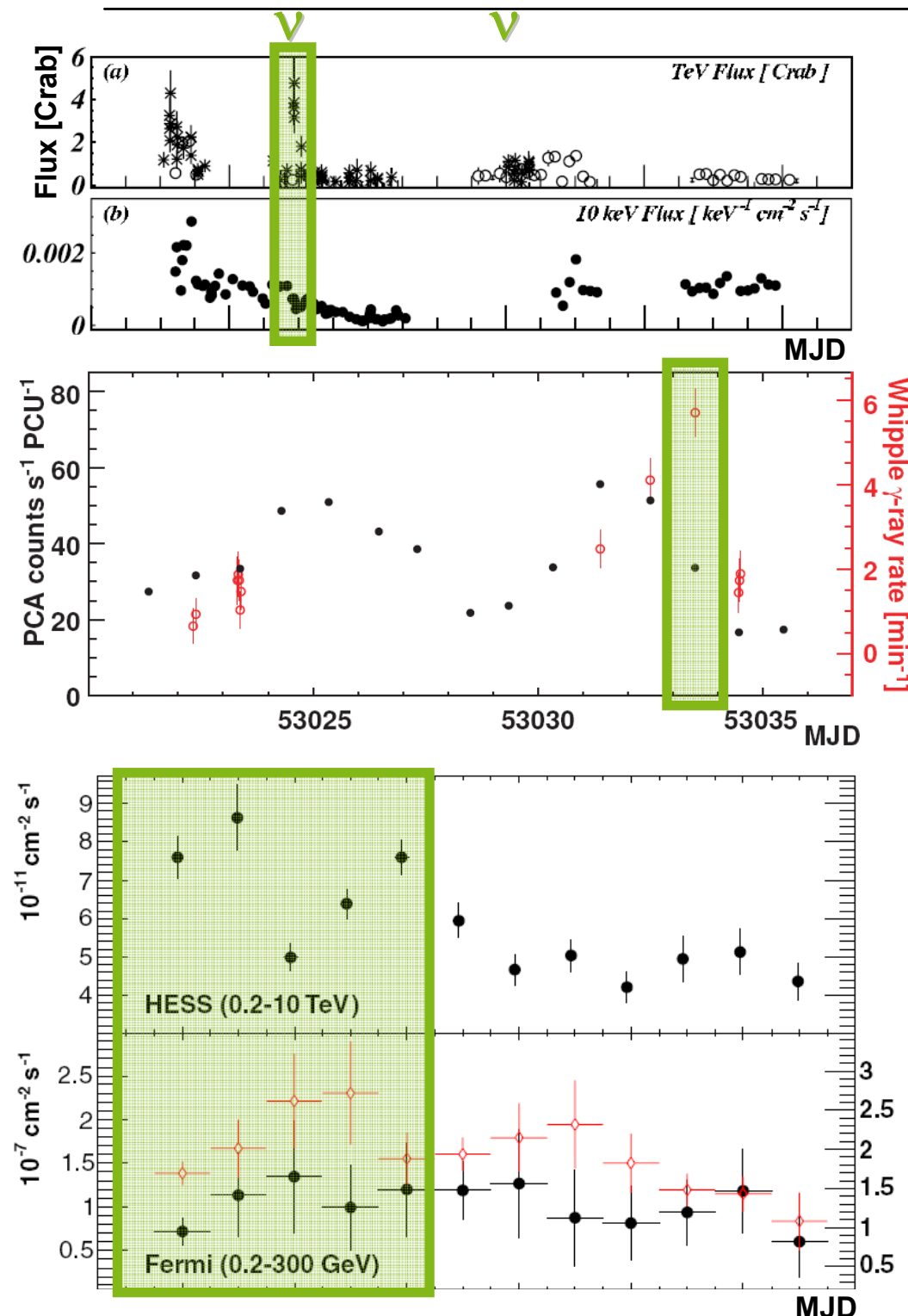
Mkn 501 lightcurve, $E > 2$ TeV



Thieler, Backes⁺ T 95.1

- Data collection ongoing
- First glance at the data quite encouraging:
 - Several methods reproduce period around 23 days in 1997 TeV data of Mkn501

Hadronic orphan flares?

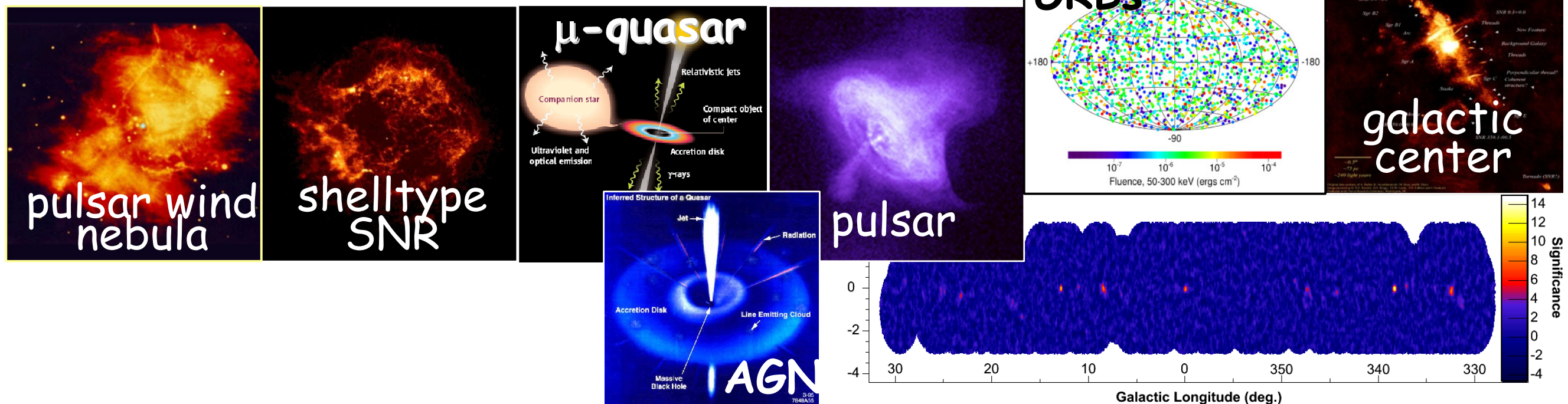


- Orphan TeV flare in 2002 of 1ES1959+650 [Krawczynski+04]
- 2 ν within 66 days, 1 coincident with orphan flare [Resconi+05]
- „Orphan“ TeV flare in 2004 of Mkn 421 [Blazejowski+05]
- PKS 2155-304: GeV lightcurve compatible with constant while in TeV highly variable [Aharonian+09]

➡ Different origins of radiation?

High sensitivity with threshold energies around 100 GeV

↪ many observation missions:



↪ no cost efficient way for 24/7 monitoring

High sensitivity with threshold energies around 100 GeV

↪ many observation missions:



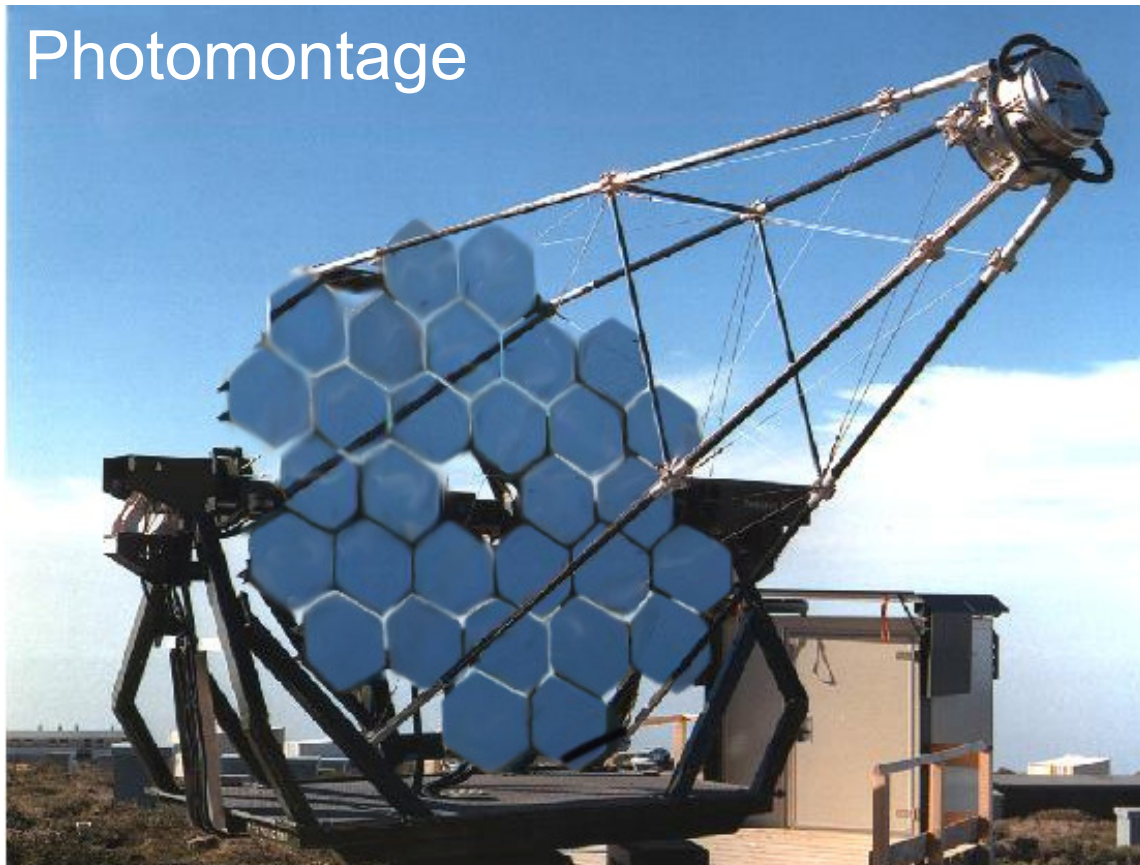
↪ no cost efficient way for 24/7 monitoring

→ **Dedicated Worldwide Agn Research Facility (DWARF)**

Idea: Affordable monitoring telescopes
observing few sources with large duty cycle

TU Dortmund, ETH Lausanne, ISDC Versoix, Uni Würzburg, ETH Zurich

Photomontage



- Mount of former HEGRA CT3 (La Palma)
- New drive system (as in MAGIC)
- New mirrors
- New camera
 - **First G-APD camera for an IACT**
 - Solid light concentrators
 - Fully embedded DAQ

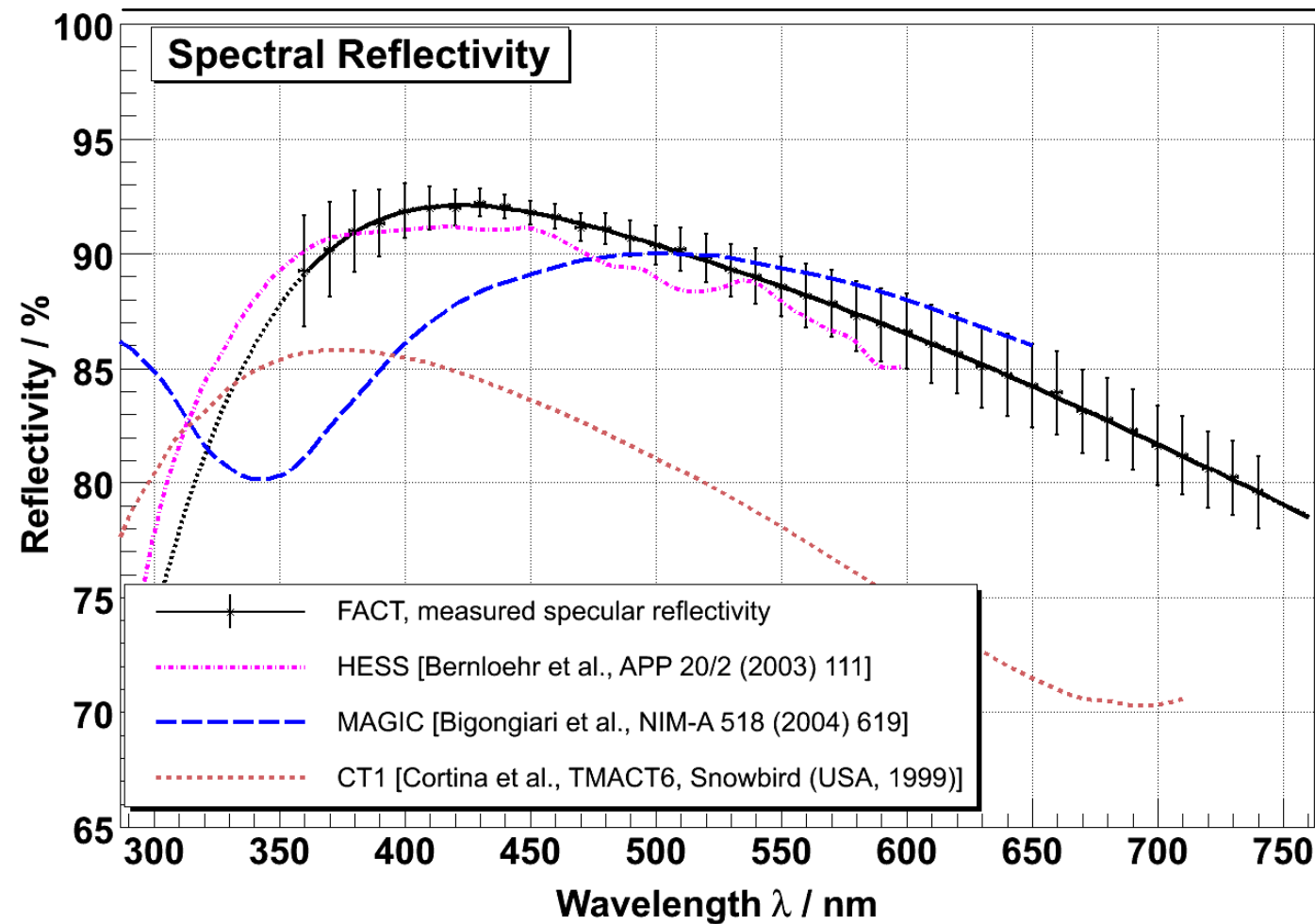
D. Neise⁺ T 96.1

MWL partners

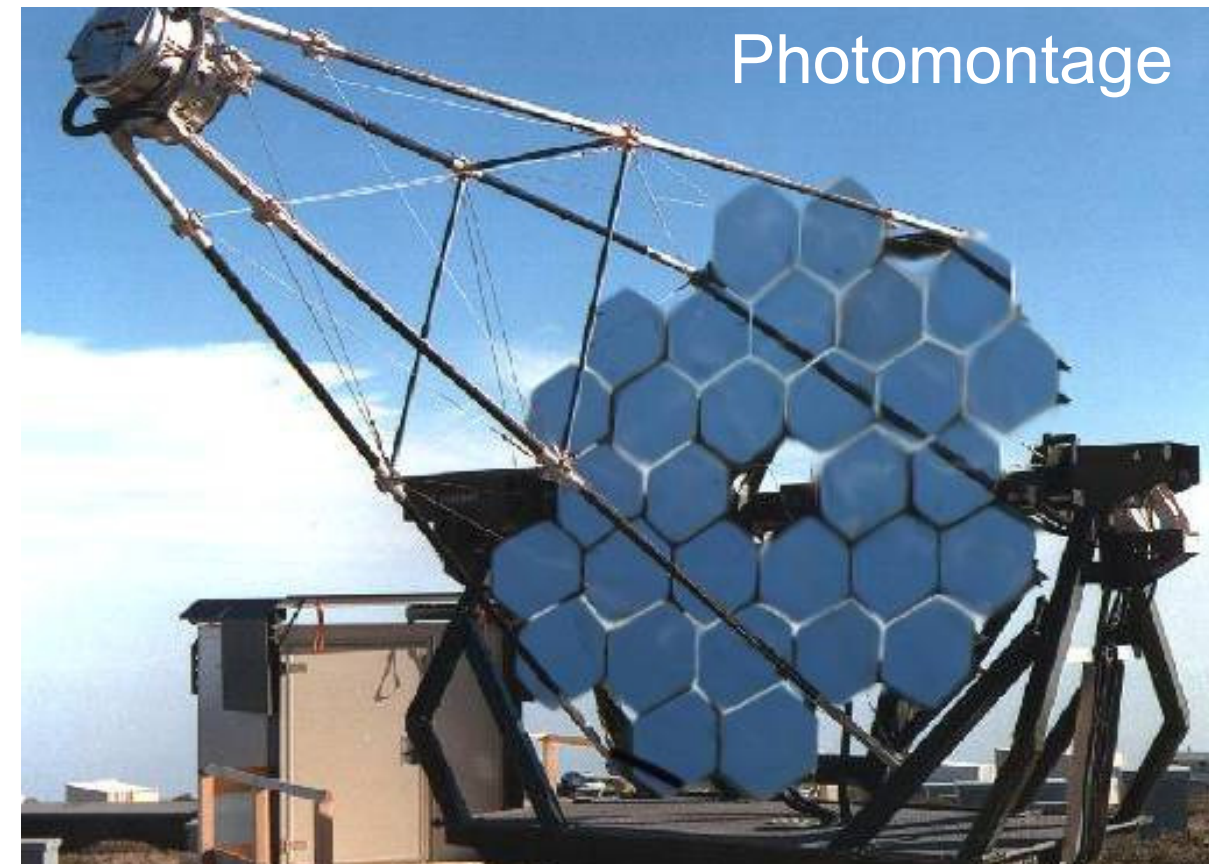
- Planck (radio all-sky)
- Metsähovi (radio)
- Tuorla (optical)
- MAXI (X-ray all-sky)
- Fermi (GeV all-sky)

Goals

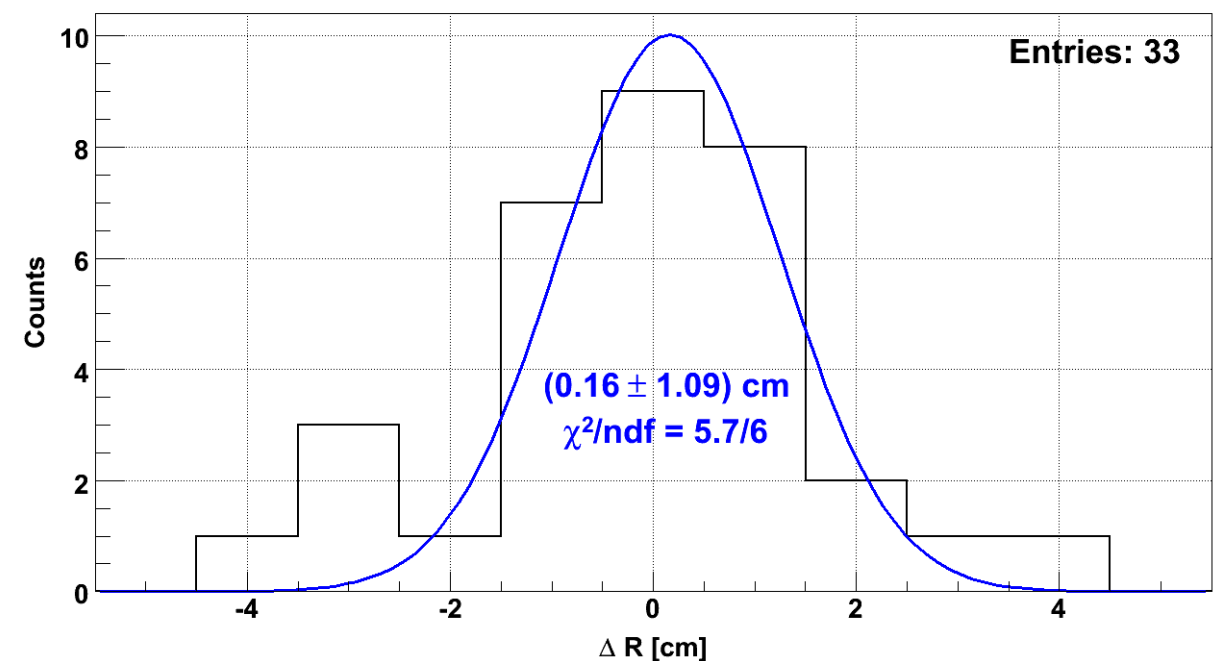
- Crab observations next season
- Test whether G-APDs are suitable for next generation IACTs (CTA, AGIS, ...)
- Long-term monitoring of near blazars in the DWARF network

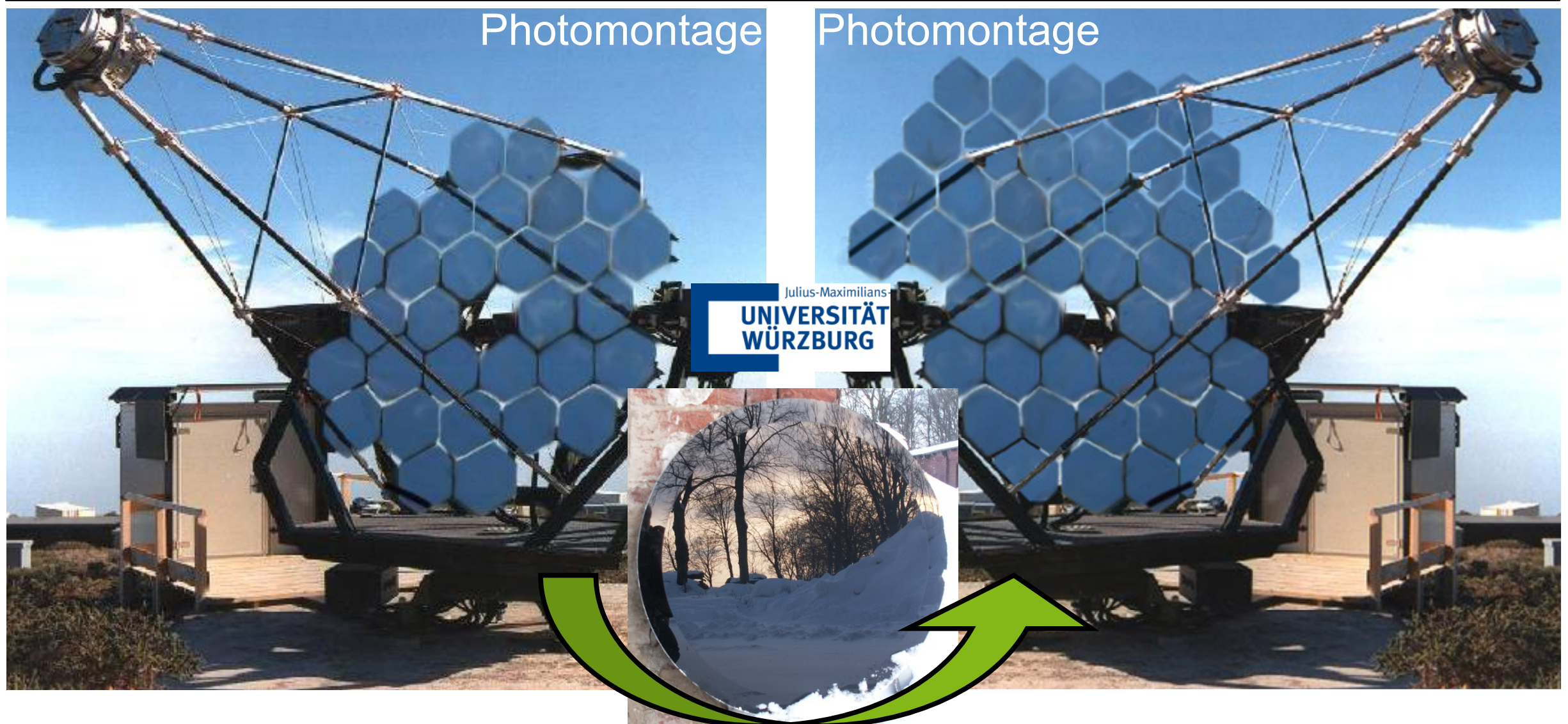


- Aluminum Mirrors from CT1 remachined and recoated
- Higher reflectivity
- Hexagonal → 9% enlargement
- 9,25m² mirror area



Deviation from nominal focal length (490cm)





Further enlargement planned:
Carbon-fiber mirrors

- Copied from a glas master
- ↪ Light-weight & inexpensive

- First prototype available
- ↪ 11,4m² effective mirror area

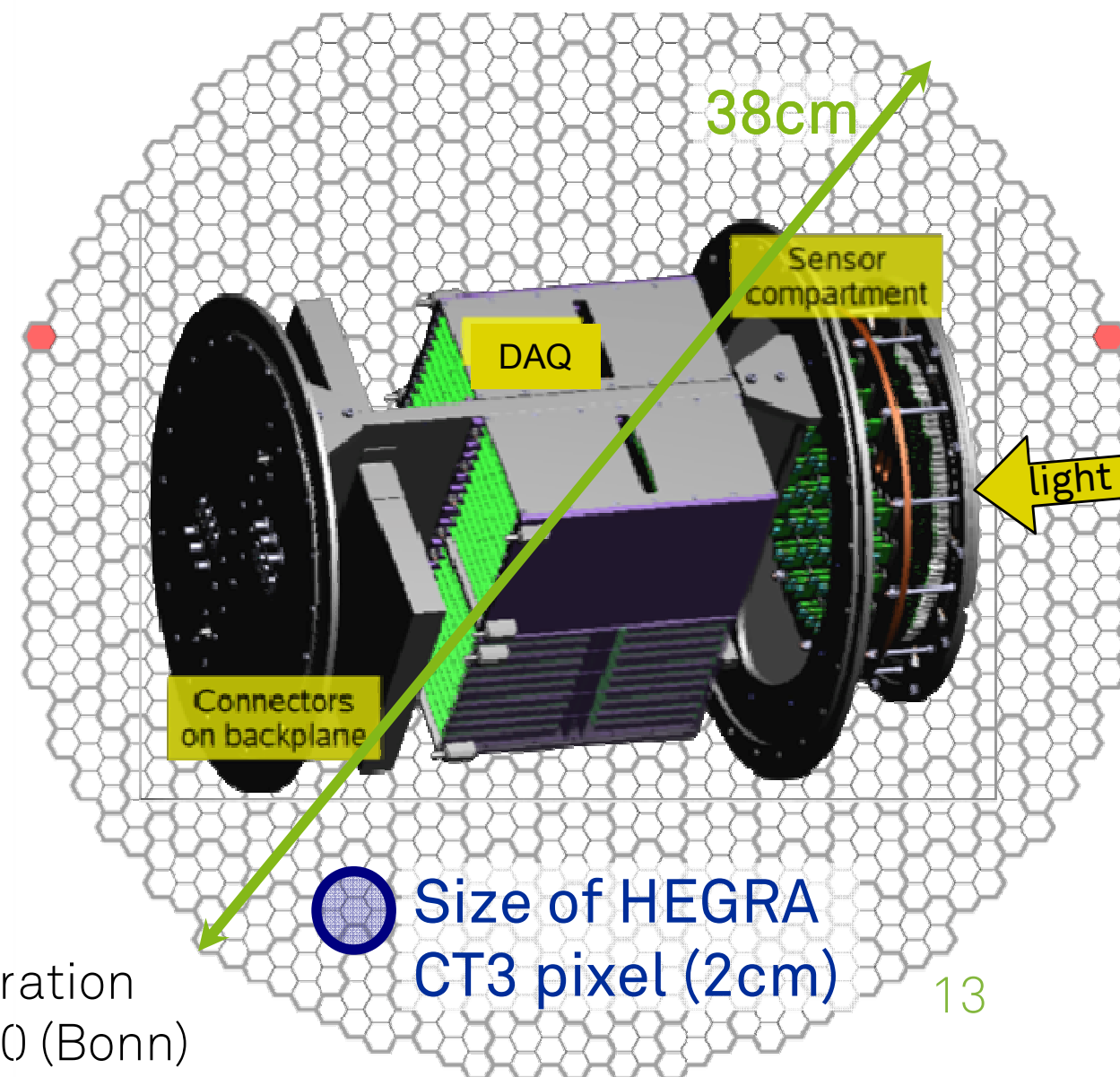
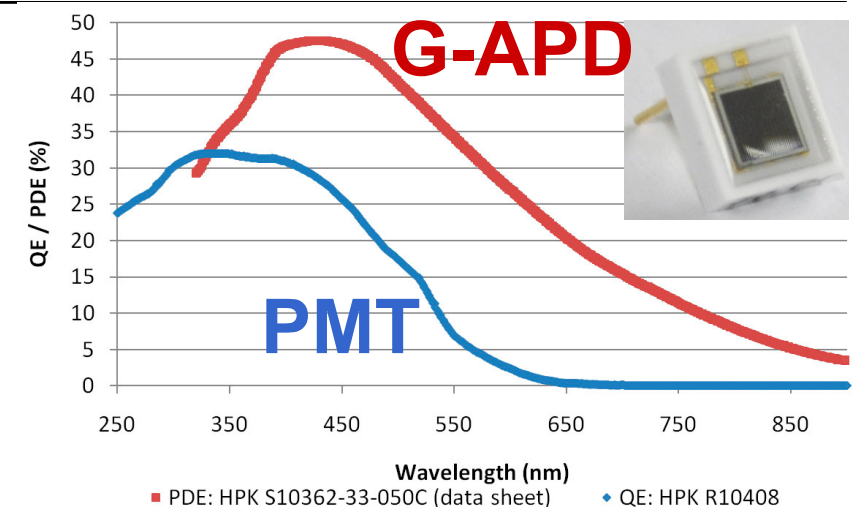
G-APDs

D. Neise⁺ T 96.1

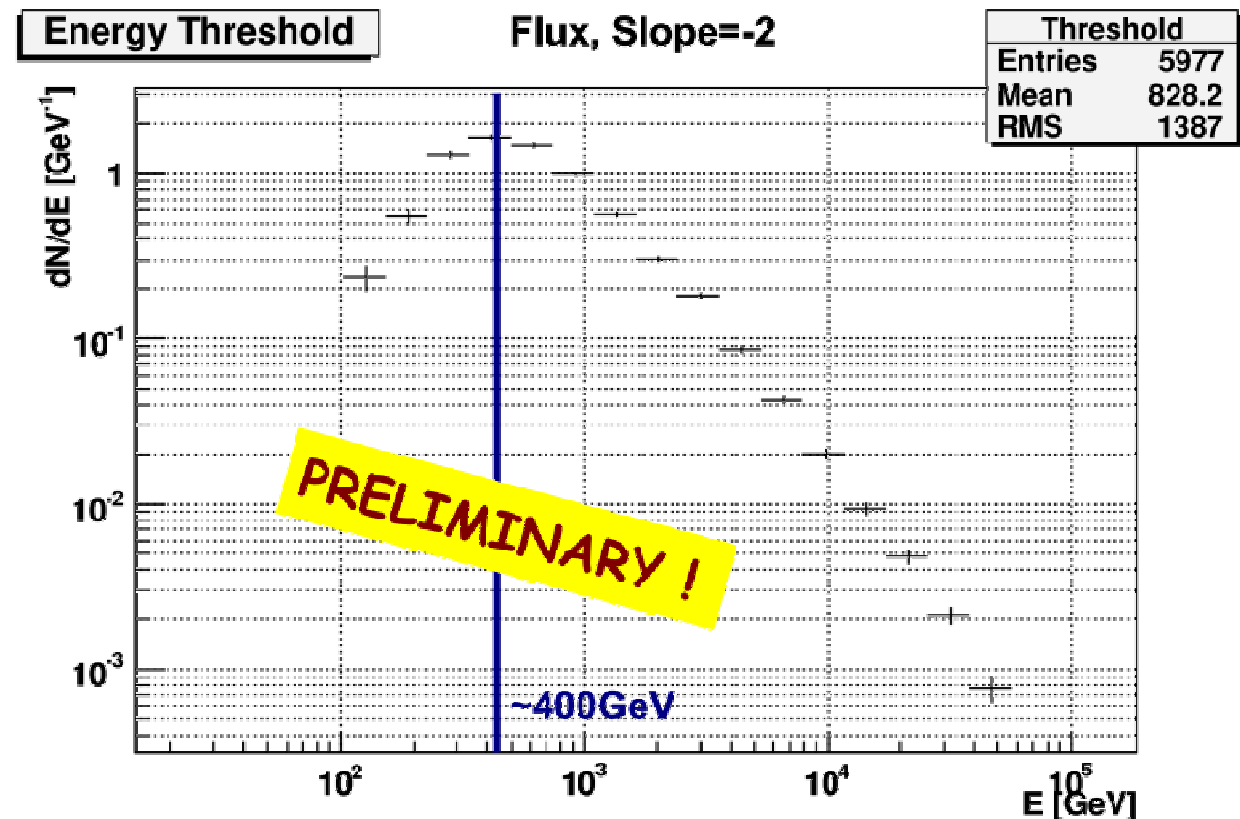
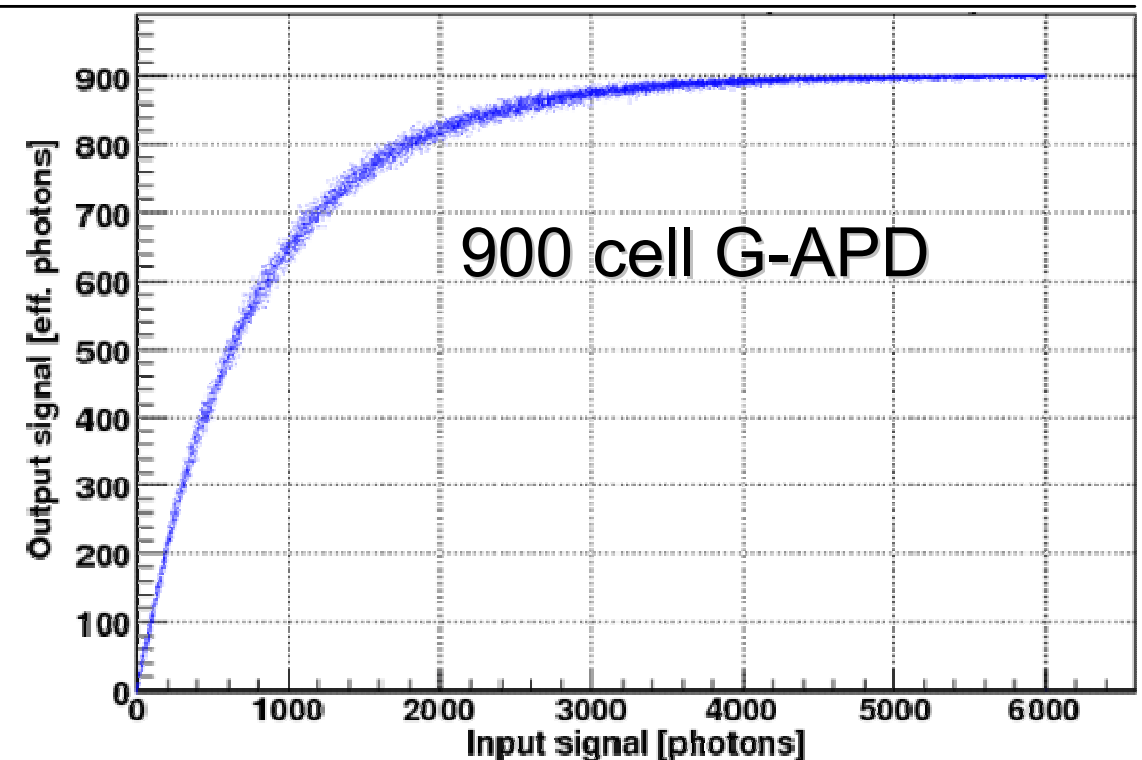
- Novel photosensors with potential to replace PMTs
- Single p.e. resolution
- High PDE
- Negligible time-jitter
- Not damaged by bright light
- Very compact & robust
- Not used in IACTs, **yet**

G-APD Camera

- 1440 Pixel
- Fully integrated DAQ
 - Based on DRS4
 - 2GHz sampling
 - Analog sum of groups of 9 pixels for trigger



- CORSIKA
 - Atmospheric transmission
 - Reflector
 - Lightguides
 - G-APDs
 - Crosstalk
 - Deadtime
 - Afterpulses
 - non-linearities
 - Several (>50) trigger layouts
 - N- multiplicity
 - N-next neighbor
 - Analog summation patches
- Analog summation performs best
- Energy threshold for reconstructed events ~400GeV

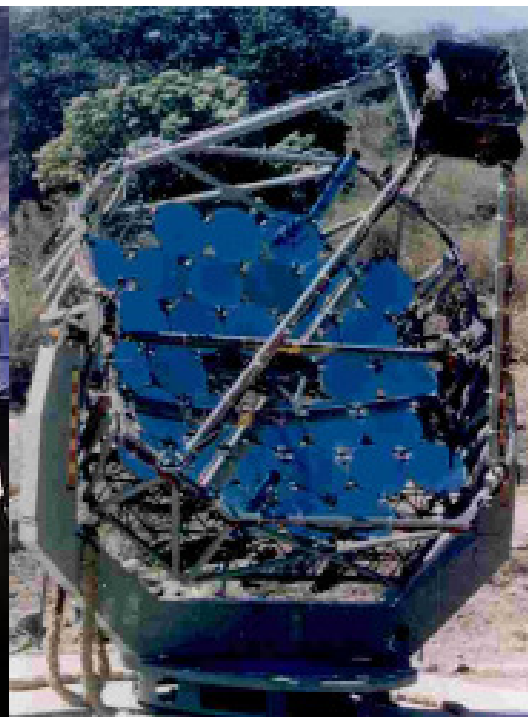


Whipple 10m



- 1 telescope
- Mt. Hopkins (Az, USA)
- ↳ $E_{th} \sim 400 \text{ GeV}$
- Ongoing monitoring
[Pichel⁺, *ICRC09*]

TACTIC



- 1 telescope
- Mt. Abu (IN)
- ↳ $E_{th} \sim 1 \text{ TeV}$
- Ongoing monitoring
[Koul⁺, *NIM07*]

OMEGA



- 2 of HEGRA
- Sierra Negra (MEX)
- **4100m a.s.l.**
- ↳ $E_{th} \sim 700 \text{ GeV} \rightarrow ???$
[Ruben⁺, *ICRC09*]

StarBase

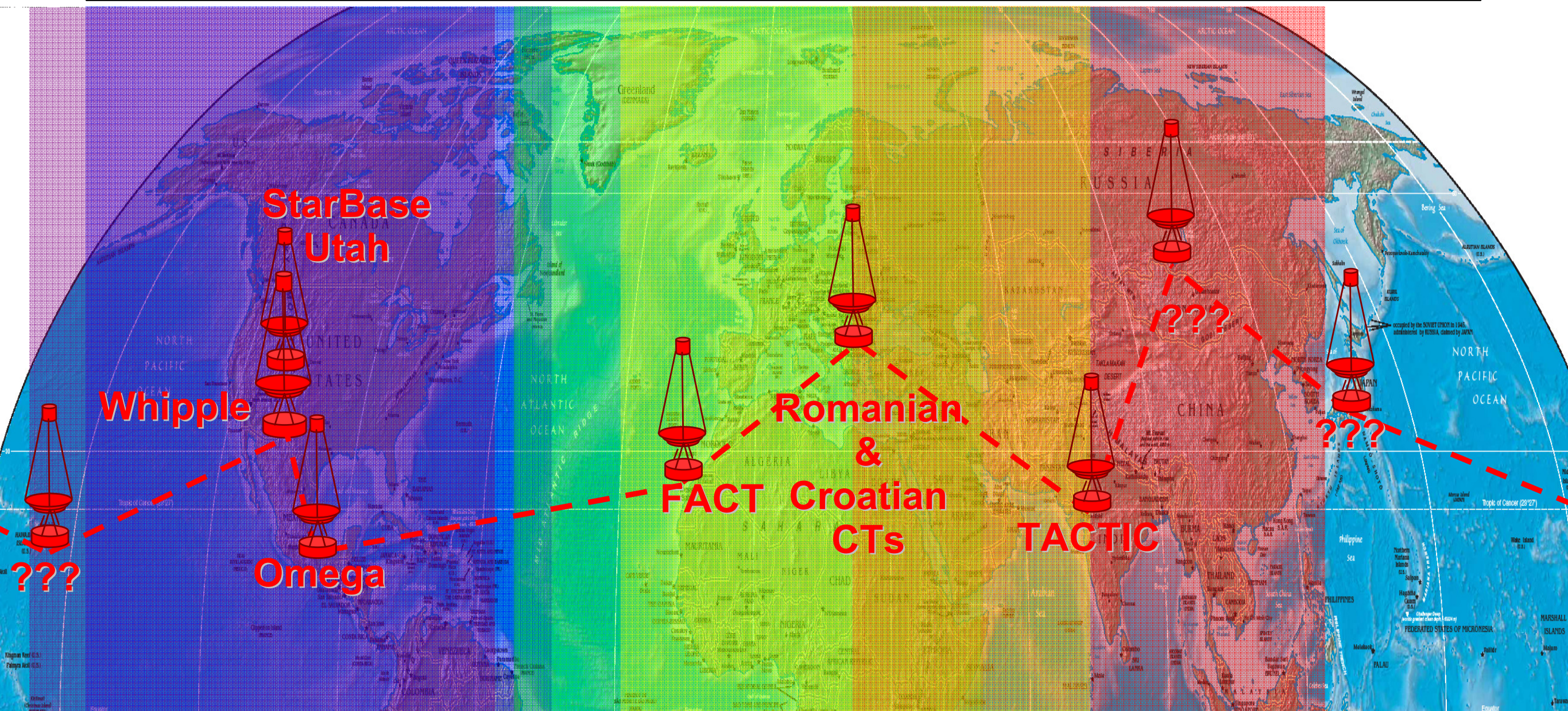


- 2 of Telescope Array
- Utah (USA)
- 7.1 m^2 mirror
- Int. Interferrometry
- No Cherenkov-camera, yet
[Finnegan⁺, *AIPC08*]

...
more
to
come!

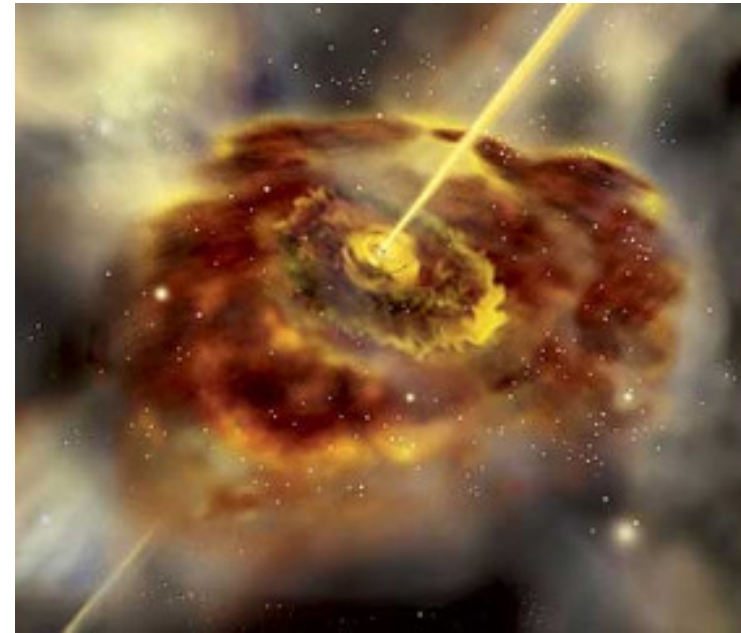


Dedicated **W**orldwide **A**gn **R**esearch **F**acility
DWARF



Dedicated **W**orldwide **A**gn **R**esearch **F**acility
DWARF

- Much interesting physics in monitoring, e.g.
 - Leptonic or hadronic jets?
 - Coincident γ - and ν -observations
 - Super Massive Binary Black Holes
 - Gravitational waves



- Not cost-efficient with latest generation IACTs

↪ Dedicated telescopes for long-term monitoring:

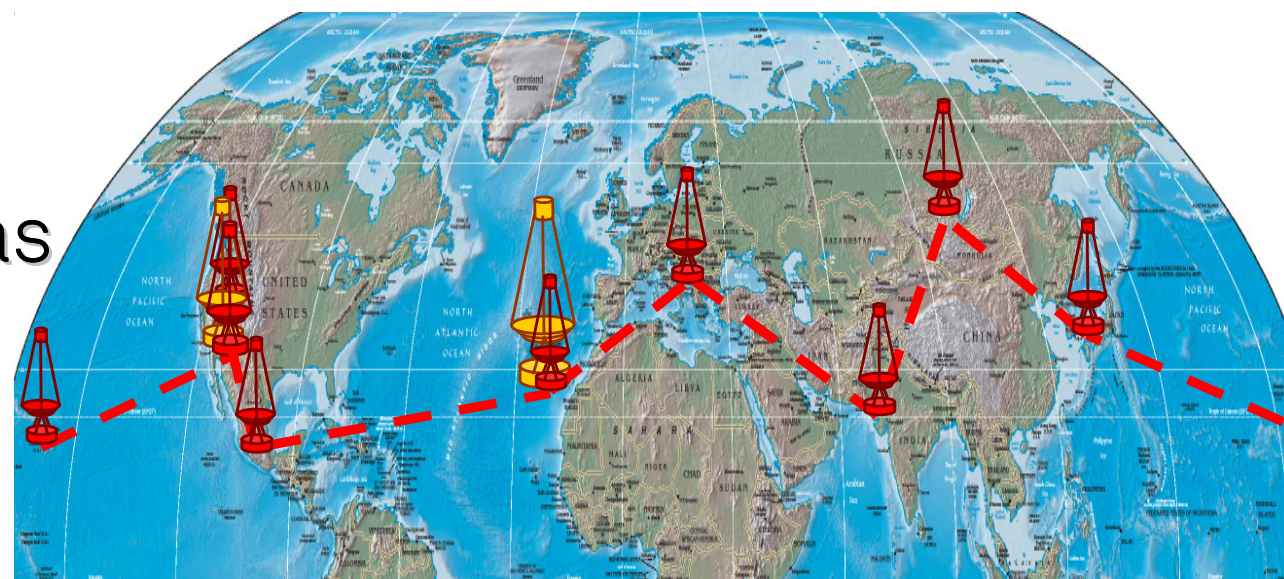


FACT

Prototype of a new generation
of IACTs with G-APD cameras

DWARF

Network of IACTs
for **24/7 observations**



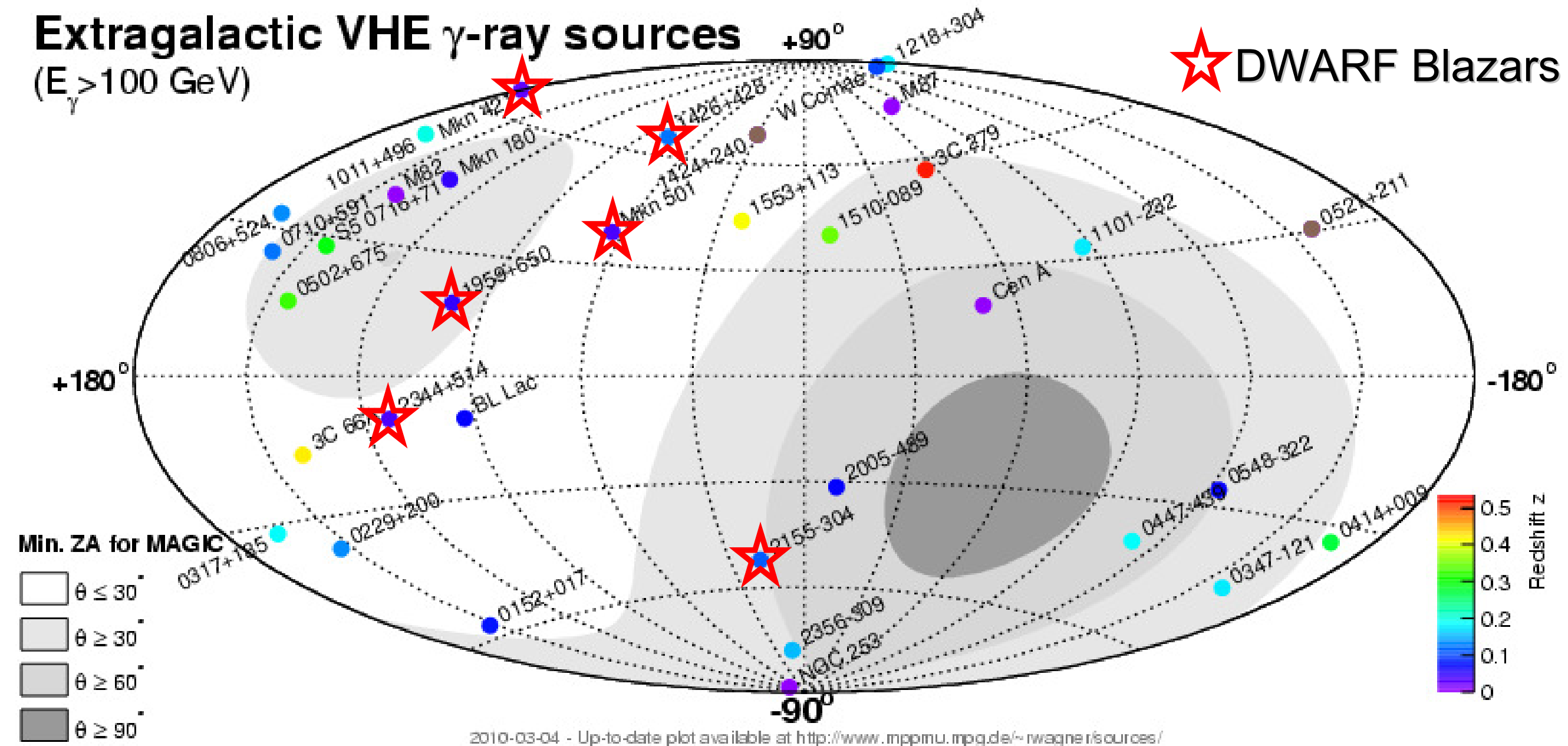
The background of the slide is a photograph of a Cherenkov telescope at dusk. The telescope's structure, including its support and the long arm holding the camera, is silhouetted against a sky with horizontal bands of pink, orange, and blue. The sun is a bright, glowing line on the horizon.

Thank you!

The **F**irst G-**A**PD **C**herenkov **T**elescope **FACT**
within the
Dedicated **W**orldwide **A**gn **R**esearch **F**acility
DWARF network

Extragalactic VHE γ -ray sources ($E_{\gamma} > 100$ GeV)

★ DWARF Blazars



Mkn 501, Mkn 421, 1ES 1959+650, 1ES 2344+514,
H1426+428, PKS 2155-304